

REPORT DOCUMENTATION PAGE				<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
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1. REPORT DATE (DD-MM-YYYY) 9 Sep 2013		2. REPORT TYPE Consultative Letter		3. DATES COVERED (From – To) April 2013 – August 2013	
4. TITLE AND SUBTITLE Unshielded Facility Nondestructive Inspection (NDI) Radiation Protection Survey for Homestead ARB, FL				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Maj Zahid Sulaiman, TSgt Phillip Heil, SSgt Michael Ames				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Occupational and Environmental Health Department/OECM 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2013-0017	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSORING/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2013-3977, 9 Sep 2013					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Radiation protection survey of the aircraft wash-rack used for unshielded NDI operations at Homestead ARB. The NDI personnel used a Lorad LPX-160 x-ray unit for inspections. Survey was performed in accordance with T.O. 33B-1-1 and applicable Air Force standards. The aircraft wash-rack was recertified as an "unshielded facility."					
15. SUBJECT TERMS NDI, unshielded facility, x-ray survey, Lorad, LPX-160, Homestead ARB, FL					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 19	19a. NAME OF RESPONSIBLE PERSON TSgt Phillip Heil
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

9 September 2013

MEMORANDUM FOR 482 MSG/SGPB

ATTN: MR. MICHAEL SCHMIDT
29050 CORAL SEA BLVD, BOX 16
HOMESTEAD ARB, FL 33039-1299

FROM: USAFSAM/OEC

2510 Fifth Street

Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2013-0017, Unshielded Facility
Nondestructive Inspection (NDI) Radiation Protection Survey for Homestead
ARB, FL

1. INTRODUCTION:

a. *Purpose:* At the request of 482 MSG/SGPB, the U.S. Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), Radiation Health Consulting Branch completed a radiation protection survey for 482 MXS/MXMFN NDI Laboratory's unshielded facility NDI operations at the aircraft wash-rack on 30 Apr 13.

b. *Background:* The purpose of this survey was to reevaluate the NDI unshielded facility for compliance with T.O. 33B-1-1, Chapter 6, *Radiographic Inspection Method*, and compliance with occupational and general public radiation safety standards. Specifically, this survey included establishing a 2-mrem/h perimeter around the unshielded facility, ensuring compliance with applicable occupational dose limits, a review of worker radiation dosimetry records, NDI's operating procedures/instructions, and radiation safety training.

c. *Survey Personnel:*

- (1) Health Physicist, USAFSAM/OEC
- (2) Lead Health Physics Technician, USAFSAM/OEC
- (3) Health Physics Technician, USAFSAM/OEC

d. *Personnel Contacted:*

- (1) Installation Radiation Safety Officer (IRSO), 482 MSG/SGPB
- (2) NDI Laboratory Supervisor, 482 MXS/MXMFN
- (3) NDI NCO, 482 MXS/MXMFN

e. *NDI Survey Measurement Equipment:*

- (1) Fluke Biomedical – 451P Pressurized Ion Chamber (Serial Number 3885, Calibrated 29 November 2012, Calibration Due 29 November 2013)
- (2) Fluke Biomedical – 451P Pressurized Ion Chamber (Serial Number 3883, Calibrated 26 July 2012, Calibration Due 26 July 2013)
- (3) Fluke Biomedical – 451P Pressurized Ion Chamber (Serial Number 3878, Calibrated 29 November 2012, Calibration Due 29 November 2013)
- (4) Fluke Biomedical – 451P Pressurized Ion Chamber (Serial Number 3881, Calibrated 20 June 2012, Calibration Due 20 June 2013)

2. METHODOLOGY:

a. *Site Layout:* Unshielded NDI operations are conducted on the Homestead ARB flight line at the aircraft wash-rack as shown in Figure 1. The aircraft wash-rack is an open-sided metal-roof- covered structure that is able to fit F-16 aircraft underneath as shown in Figure 2. The rear of the aircraft wash-rack has an approximately 8-foot-high concrete wall that runs the entire width of the wash-rack stall as shown in Figure 3.



Figure 1. Overhead view of survey area



Figure 2. Aircraft wash-rack



Figure 3. Concrete wall rear of aircraft wash-rack

b. *Radiation Survey*: Radiation measurements were taken at the NDI operator's console position, at 75 feet from the aircraft wash-rack at the control line, and at the 2-mrem/h line around the entire aircraft wash-rack, as seen in Figure 4 in the Results section. In total, 31 measurements were taken to establish the 2-mrem/h line for both the left and right wing operations. Additionally, measurements were taken to document exposure at the rear wall and 1 meter from the tube head. The x-ray tube head was placed on the ground and directed at the underside of the aircraft wing and fuselage to characterize current/past unshielded NDI operations. This was repeated on each side of the aircraft to show full coverage and/or worst case x-ray exposure possibilities. Measurements were made with the x-ray tube (Lorad LPX-160) lying on the ground pointing toward the aircraft to maximize x-ray scatter during this particular NDI operation. The power was set to 150 kVp and 5 mA for all measurements.

c. *General Radiation Safety Review*: General radiation safety protocols were reviewed using the checklist in Attachment 1 that is based upon T.O. 33B-1-1, 10 CFR 20, and AFMAN 48-125, *Personnel Ionizing Radiation Dosimetry*.

- (1) Verify unshielded NDI safety procedures meet T.O. 33B-1-1 and other occupational safety and health requirements.
- (2) Verify an adequate number of personal monitoring devices were available and operational. Observe personnel correctly wearing these devices while performing NDI operations.
- (3) Verify all radiation exclusion/controlled areas were properly established as required by T.O. 33B-1-1. Ensure controlled radiation area was cordoned off with cones and rope barriers marked with appropriate signage as required by T.O. 33B-1-1.

3. RESULTS:

a. The radiation survey established a new recommended controlled area line as shown in Figure 4. The new recommended controlled area extends the current barrier to the southwest and southeast and establishes a new barrier line to the grass area to the northeast of the aircraft wash-rack. Measurements were taken in the area of the concrete wall to the rear of the aircraft wash-rack. The wall provides a high degree of shielding, albeit unintentional, while NDI operations are taking place. The 2-mrem/h line was found to be at the same location as the concrete jersey barriers, parallel to the rear wall, when measured from chest height. Measurements and dose estimates can be seen in Tables 1 and 2. The survey showed compliance with the occupational dose limit of 5 rem/yr and general public radiation dose limit of 100 mrem/yr. However, when measurements were taken above the height of the concrete wall, the hourly and annual dose limits were exceeded as shown in Table 2.

b. A general radiation safety review resulted in the following observations.

- (1) Unshielded NDI safety procedures meet occupational safety and health requirements as specified within T.O. 33B-1-1, 10 CFR 20, and AFMAN 48-125.

- (2) An adequate number of personal monitoring devices were available and operational. Personnel were observed correctly wearing these devices while performing NDI operations.
- (3) Procedures establishing the exclusion/controlled areas were properly implemented.
- (4) Controlled areas exhibited proper visual warnings, barrier ropes, and radiation warning signs. Audible warnings were not observed to be in place. Interlocks preventing activation unless a warning light was connected were observed to be functioning.
- (5) At least two serviceable, properly calibrated radiation survey meters were in use by NDI personnel. In addition, at least one qualified radiographer was present during all operations.

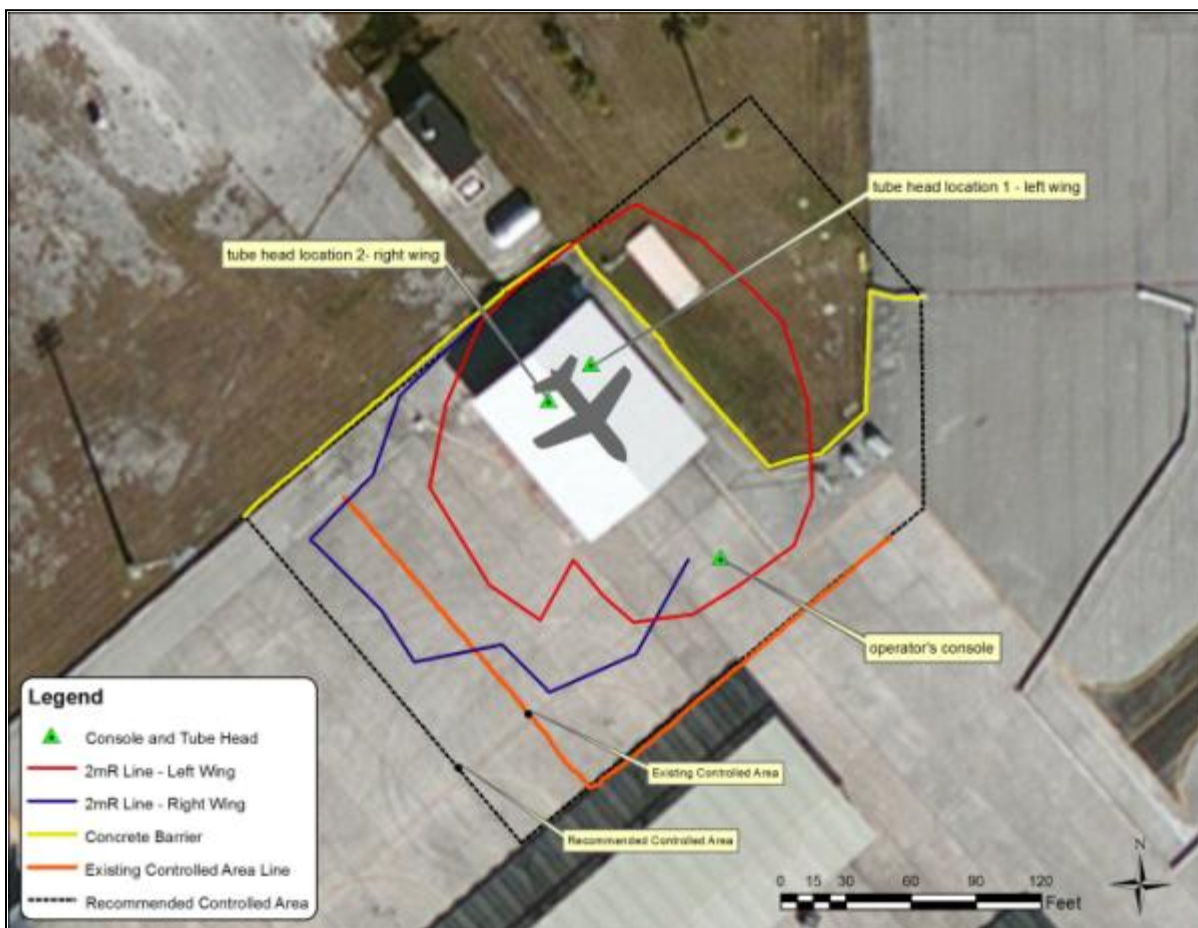


Figure 4. Homestead Air Reserve Base Unshielded NDI Survey Map

Table 1. Maximum Estimated Workload Summary

Exposure Type	Technique				Exposures per Year	Maximum Estimated Exposure Duration (h) ^c	Estimated Beam On – Time (h/yr) ^d
	kVp	mA	Min ^a	Exp ^b			
Average AFTO 125 Documented Settings	145	5	23	4	58	0.4	22

^aAveraged exposure time (min) per series = number of exposures in series x maximum exposure time in series / 15 series/yr.

^bAverage number of exposures per series.

^cExposure duration (h) = (averaged exposure time [min]) / (60 min/h)

^dBeam on time (h/yr) = (exposures/yr) x (exposure duration in hours)

Table 2. Survey Measurements and Dose Rate Estimated

Diagram Location	Description	451P Serial No.	451P Bkg Reading (mR/h)	Area ^a	Highest Reading (uR/h)	Updated Reading (mR/h)	Occupancy Factor	Max Estimated 1- h Dose (mrem) ^b	Max Estimated 1- yr Dose (mrem) ^c	Exceeds 2 mrem in any 1 h?	Exceeds 100 mrem/yr
Operator's console	@ 14 in from ground	3881	0.007	C	2000	1.9	1	0.8	43.5	No	No
Controlled area line directly behind console	chest height	3883	0.007	C	500	0.5	1	0.2	10.9	No	No
1 m from tube head	on ground	3878	0.007	C	866666	866.7	1	325.2	18861.2	Yes	Yes
Wall rear of wash-rack	top of wall (8 ft)	3885	0.01	U	13000	12.9	1	4.9	282.9	Yes	Yes
2-mR Line	chest height	3885	0.007	C	2000	1.9	1	0.8	43.5	No	No

^aArea: C, Controlled Area; An area controlled by the NDI section and where workers have completed ALARA training. U, Uncontrolled Area; An area not controlled or monitored by the NDI section and where workers have not completed ALARA training.

^bMax dose estimate for 1 h = (updated reading [mrem/h])*(exposure duration [h]).

^cAnnual dose estimate = (updated reading [(mrem/h)]*(occupancy factor)*(total estimated beam on time in h/yr).

4. DISCUSSION:

a. The workplace Industrial Radiography Utilization Log, AFTO IMT 125, contains eight blocks from which different monitoring positions and the associated maximum observed dose rate can be annotated. For all past unshielded operations, to include this survey, three locations were annotated with a dose rate in mR/h. However, only two operational SM-400 ionization chamber instruments were in use by NDI personnel during this survey, and only two locations were observed to be measured by NDI personnel with the two available instruments. It can be assumed that the second and third locations are at the controlled area perimeter; however, the exact locations are not documented during unshielded NDI operations.

b. The electronic personal dosimeters (EPDs) worn by NDI personnel had not been cleared of previous radiation dose data. Data on the EPDs showed a cumulative radiation dose over a period of time since the last time they had been cleared out. This is a finding that had been noted previously when USAFSAM personnel completed a Shielded NDI Facility Survey for the 482nd NDI laboratory.

5. CONCLUSIONS AND RECOMMENDATIONS:

a. Increase and completely enclose restricted area by using additional rope barriers, cones, and signage as shown in Figure 4. It will prevent unauthorized personnel from accidentally wandering into the area where NDI operations may be taking place. Additionally, posting “Caution Radiation Area” signs on the back wall of the aircraft wash-rack during NDI operations will prevent accidental exposure to personnel who may be unaware of ongoing NDI operations. Refer to T.O. 33B-1-1, para 6.8.8.2 for guidance.

b. Additional Qualified Radiographers or Radiation Safety Monitor Assistants should be used to maintain visibility with the rear of the wash-rack during operations. This requirement is spelled out in T.O 33B-1-1, section 6.8.8.2.5, para a.

c. Ensure that Industrial Radiography Utilization Logs (AFTO IMT 125) are accurately and legibly filled out.

d. To avoid speculation or uncertainty regarding the specific monitoring locations and the associated maximum dose rate on the AFTO IMT 125, detailed descriptions of each monitoring position should be documented and reviewed by all personnel prior to performing radiography work.

d. Clear out previously recorded dose data on EPDs to ensure accuracy of their measurement during current operations and to prevent incorrect doses from being recorded on the AFTO IMT 115. The “Easy EPD” software and infrared transmitter/receiver should be available on at least one computer in the work center.

e. The offices responsible for CE operations as well as the MOC (Maintenance Operations Center) should be informed of unshielded NDI operations taking place at this location.

f. Any changes to NDI operations or to the aircraft wash-rack will require revalidation by qualified personnel.

6. If you have any questions regarding this report, please contact TSgt Phillip Heil at DSN 798-3412 or phillip.heil@wpafb.af.mil.

A handwritten signature in black ink, reading "Brian D. Shuler". The signature is fluid and cursive, with a horizontal line extending from the end of the name.

BRIAN D. SHULER, Capt, USAF, BSC
Chief, Radiation Consulting Branch

2 Attachments:

1. Unshielded Nondestructive Inspection Survey Form
2. Instrument Calibration Sheets

Attachment 1
UNSHIELDED NONDESTRUCTIVE INSPECTION SURVEY FORM

Survey Performed By: USAFSAM/OEC
 Radiation Health Consulting Branch

Survey Date: 30 Apr 2013

Reviewed and Approved By: Installation Radiation Safety Officer, 482nd FW

I. FACILITY IDENTIFICATION:

A. Base: Homestead ARB

B. Bldg Number: Aircraft Wash-Rack

C. State/Country: FL, USA

D. Room Number: N/A

E. Command: AFRC

F. Phone Number (DSN): 535-7350

G. Organization: 482 MXS/MXMFN

H. WPI: 0088-FAND-404A

II. PERSONNEL:

TITLE

Shop Chief, NDI
 NDI Technician

ROLE/RESPONSIBILITY

Radiographer in Charge (RIC)
 Radiation Safety Monitor

III. EQUIPMENT IDENTIFICATION:

Manufacturer / Model Number	Serial Number	Maximum kVp	Maximum mA
LORAD / LPX-160	CO496446 (Console) X0496449 (X-Ray Tube)	150	5

IV. DOSE ASSESSMENT AND PERSONNEL MONITORING:

YES NO N/A

A. Persons adequately monitored (10 CFR 20.1502; T.O. 33B-1-1, 6.8.5.3)

☒ ☐ ☐

B. Thermoluminescent device available

☒ ☐ ☐

1. One per radiographer

☒ ☐ ☐

2. Worn during radiography

☒ ☐ ☐

3. TLDs properly stored (AFMAN 48-125; T.O. 33B-1-1, 6.8.5.4.4)

☒ ☐ ☐

4. TLDs returned to storage rack at the end of the work day

☒ ☐ ☐

5. TLD exchange frequency:

Quarterly

6. TLD review period:

Quarterly

	<u>YES</u>	<u>NO</u>	<u>N/A</u>
C. Pocket ionization chamber (PIC) or electronic personal dosimeter (EPD) available	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1. Proper central storage location for PIC/EPDs and control	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Date of last usage		22 Feb 13	
3. Quantity of dosimeters on-hand:		6	
Quantity at PMEL:		0	
4. Sufficient number on-hand	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Worn during radiography	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Calibration interval		Annual	
Calibration of all on-hand current	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. All function properly	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. EPD audible alarm checked prior to each work day	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
9. EPD audible alarm set at dose <500 mR?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Utilization log available (T.O. 33B-1-1, 6.3.10.2.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Readings recorded daily (Unshielded Operations)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Date of last entry:		30 Apr 13	
12. Real-time dosimeter log maintained for 3 years	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Exposures within limits (10 CFR 20.120; T.O. 33B-1-1, 6.8.5.2.1.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Prior cumulative occupational doses obtained/attempted 10 CFR 20.210)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Exposure data supplied to workers annually (10 CFR 19.13)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

V. Standard Operating Procedures:

	<u>YES</u>	<u>NO</u>	<u>N/A</u>
1. Procedures clearly define radiation exclusion/controlled areas	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Areas properly established and adequately controlled	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Audible warnings	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Visible warnings	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Interlocks	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Delay switches	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Emergency shut-off (ESO) switches	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Restricted areas roped off to control access during irradiation operations	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. Safety monitors designated to control restricted areas where other controls are not practical?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Doses in controlled areas and environments meet general public limits (T.O. 33B-1-1, 6.8.8.2.4b)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. At least two individuals to include one qualified radiographer are in attendance during all radiographic operations?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. At least two serviceable, properly calibrated radiation survey meters are in use during unshielded Ops	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Restrict use of X-radiography equipment to qualified radiographers	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Clearly define emergency procedures and designate individuals to be	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Clearly define responsibilities and actions to be taken to investigate overexposures to radiation	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Mandate recording of records of radiation surveys to document that radiation safety surveys are actually being performed prior to each radiography operation	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Ensure that x-ray equipment is adequately secured when not in use to preclude unauthorized use	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Attachment 2 Instrument Calibration Sheets

AIR FORCE PRIMARY STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION

Report Number: 123320178 Department: Photonics/Nucleonics Date of Issue: 20121129

Calibration Item:

Manufacturer: FLUKE BIOMEDICAL
Model/Part No.: 451P SERIES
Equipment Type: ION CHAMBER SURVEY METER

Serial Number: 0000003878
ID Number: F162864

Equipment Submitted by:

88 MSG/LGRMD
5060 PEARSON ROAD
WRIGHT PATTERSON AFB, OH, 45433-5517

Item Condition:

As Received: IN-TOLERANCE

The measured values of all parameters tested or calibrated were found to be within specification limits.

As Returned: IN-TOLERANCE

Item was calibrated and returned in-tolerance. This includes TO directed limitations.

Room Ambient Conditions:

Temperature: 73 °F

Relative Humidity: 36 %

Barometric Pressure: N/A

Remarks:

Traceability: Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

General Conditions:

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations, complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

Calibrated By:

Chris Morris **Metrology Technician**



Approved By:

Donald M. Hayes **Lead Metrology Technician**



Phone: (740) 788-5451

E-mail: Christopher.Morris.ctr@afmetcal.af.mil

Phone: (740) 788-5451

E-mail: Don.Hayes.ctr@afmetcal.af.mil



813 Irving-Wick Drive West, Heath, Ohio 43056-6118 TEL: (740) 788-5400 FAX: (740) 788-5404

Report Number: 123320178
Date of Issue: 20121129
Model/Part No.: 451P SERIES
Serial Number: 0000003878

Procedures and Equipment Used

PROCEDURES

Procedure
33K7-4-93-1

Date
30 Nov 2003

EQUIPMENT

Nomenclature
CESIUM-137 STANDARD

Model/Part No.
81-10

ID No.
P71063

NIST Report No.
N/A

Cal Due Date
20151010

The reported value(s) and uncertainties resulting from the measurement process are:

Report of Measurement

Range mR/hr	Applied mR/hr	T.I. Reading mR/hr
0 - 0.5	0.4	0.396
0 - 5	1.0	0.95
0 - 5	4.0	3.88
0 - 50	10.0	10.0
0 - 50	40.0	39.4
0 - 500	100	100
0 - 500	400	392
R/hr	R/hr	R/hr
0 - 5	1.0	0.99
0 - 5	4.0	4.26

- The instrument calibration results are accurate to within $\pm 10\%$ of reading between 10 and 100% full scale on any range, exclusive of energy response.



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AIR FORCE PRIMARY STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION

Report Number: 121710063 Department: Photonics/Nucleonics Date of Issue: 20120620

Calibration Item:

Manufacturer: FLUKE BIOMEDICAL
Model/Part No.: 451P SERIES
Equipment Type: ION CHAMBER SURVEY METER

Equipment Submitted by:

88 MSG/LGRMD
5060 PEARSON ROAD
WRIGHT PATTERSON AFB, OH, 45433-5517

Serial Number: 0000003881
ID Number: F160579

Item Condition:

As Received: IN-TOLERANCE

The measured values of all parameters tested or calibrated were found to be within specification limits.

As Returned: IN-TOLERANCE

Item was calibrated and returned in-tolerance. This includes TO directed limitations.

Room Ambient Conditions:

Temperature: 72.66 °F Relative Humidity: 48.6 % Barometric Pressure: N/A

Remarks:

Traceability: Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

General Conditions:

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations, complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

Calibrated By:

Mark Cooperrider Metrology Technician



Approved By:

Curtis A. Brissette Metrology Technician



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E-mail: Mark.Cooperrider.ctr@afmetcal.af.mil

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813 Irving-Wick Drive West, Heath, Ohio 43056-6118 TEL: (740) 788-5400 FAX: (740) 788-5404

Report Number: 121710063
Date of Issue: 20120620
Model/Part No.: 451P SERIES
Serial Number: 0000003881

Procedures and Equipment Used

PROCEDURES

Procedure
33K7-4-93-1

Date
30 Nov 2003

EQUIPMENT

Nomenclature
CESIUM-137 STANDARD

Model/Part No.
81-10

ID No.
P71065

NIST Report No.
N/A

Cal Due Date
20140519

The reported value(s) and uncertainties resulting from the measurement process are:

Report of Measurement

Range mR/hr	Applied mR/hr	T.I. Reading mR/hr
0 - 0.5	0.4	0.401
0 - 5	1.0	1.01
0 - 5	4.0	4.05
0 - 50	10.0	10.0
0 - 50	40.0	39.8
0 - 500	100	100
0 - 500	400	396
R/hr	R/hr	R/hr
0 - 5	1.0	0.98
0 - 5	4.0	4.18

- The instrument calibration results are accurate to within $\pm 10\%$ of reading between 10 and 100% full scale on any range, exclusive of energy response.



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AIR FORCE PRIMARY STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION

Report Number: 121730026

Department: Photonics/Nucleonics

Date of Issue: 20120726

Calibration Item:

Manufacturer: FLUKE BIOMEDICAL

Model/Part No.: 451P SERIES

Equipment Type: ION CHAMBER SURVEY METER

Serial Number: 0000003883

ID Number: F160578

Equipment Submitted by:

88 MSG/LGRMD

5060 PEARSON ROAD

WRIGHT PATTERSON AFB, OH, 45433-5517

Item Condition:

As Received: UNKNOWN or Not applicable

The item was not calibrated by the PMEL and/or the calibration condition as received can NOT be determined.

As Returned: IN-TOLERANCE

Item was calibrated and returned in-tolerance. This includes TO directed limitations.

Room Ambient Conditions:

Temperature: 72.92 °F

Relative Humidity: 50.4 %

Barometric Pressure: N/A

Remarks:

Traceability: Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

General Conditions:

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations, complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

Calibrated By:

Mark Cooperrider Metrology Technician



Phone: (740) 788-5451

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Approved By:

Donald M. Hayes Lead Metrology Technician



Phone: (740) 788-5451

E-mail: Don.Hayes.ctr@afmetcal.af.mil



813 Irving-Wick Drive West, Heath, Ohio 43056-6118

TEL: (740) 788-5400

FAX: (740) 788-5404

Report Number: 121730026
Date of Issue: 20120726
Model/Part No.: 451P SERIES
Serial Number: 0000003883

Procedures and Equipment Used

PROCEDURES

Procedure
33K7-4-93-1

Date
30 Nov 2003

EQUIPMENT

Nomenclature
CESIUM-137 STANDARD

Model/Part No.
81-10

ID No.
P71065

NIST Report No.
N/A

Cal Due Date
20140519

The reported value(s) and uncertainties resulting from the measurement process are:

Report of Measurement

Range mR/hr	Applied mR/hr	T.I. Reading mR/hr
0 - 0.5	0.4	0.414
0 - 5	1.0	0.99
0 - 5	4.0	3.99
0 - 50	10.0	9.9
0 - 50	40.0	39.2
0 - 500	100	100
0 - 500	400	394
R/hr	R/hr	R/hr
0 - 5	1.0	0.95
0 - 5	4.0	3.93

- The instrument calibration results are accurate to within $\pm 10\%$ of reading between 10 and 100% full scale on any range, exclusive of energy response.



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AIR FORCE PRIMARY STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION

Report Number: 123320180

Department: Photonics/Nucleonics

Date of Issue: 20121129

Calibration Item:

Manufacturer: FLUKE BIOMEDICAL
Model/Part No.: 451P SERIES
Equipment Type: ION CHAMBER SURVEY METER

Equipment Submitted by:

88 MSG/LGRMD
5060 PEARSON ROAD
WRIGHT PATTERSON AFB, OH, 45433-5517

Serial Number: 0000003885
ID Number: F162863

Item Condition:

As Received: IN-TOLERANCE

The measured values of all parameters tested or calibrated were found to be within specification limits.

As Returned: IN-TOLERANCE

Item was calibrated and returned in-tolerance. This includes TO directed limitations.

Room Ambient Conditions:

Temperature: 73 °F

Relative Humidity: 36 %

Barometric Pressure: N/A

Remarks:

Traceability: Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

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2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

Calibrated By:

Chris Morris **Metrology Technician**



Approved By:

Donald M. Hayes **Lead Metrology Technician**

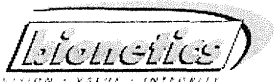


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Report Number: 123320180
Date of Issue: 20121129
Model/Part No.: 451P SERIES
Serial Number: 0000003885

Procedures and Equipment Used

PROCEDURES

Procedure
33K7-4-93-1

Date
30 Nov 2003

EQUIPMENT

Nomenclature
CESIUM-137 STANDARD

Model/Part No.
81-10

ID No.
P71063

NIST Report No.
N/A

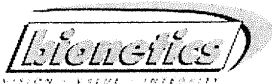
Cal Due Date
20151010

The reported value(s) and uncertainties resulting from the measurement process are:

Report of Measurement

Range mR/hr	Applied mR/hr	T.I. Reading mR/hr
0 - 0.5	0.4	0.398
0 - 5	1.0	0.96
0 - 5	4.0	3.9
0 - 50	10.0	9.9
0 - 50	40.0	39.3
0 - 500	100	100
0 - 500	400	390
R/hr	R/hr	R/hr
0 - 5	1.0	0.98
0 - 5	4.0	4.16

- The instrument calibration results are accurate to within $\pm 10\%$ of reading between 10 and 100% full scale on any range, exclusive of energy response.



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